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ABSTRACT

This overview deals with studies bearing on the role which information on research and development plays in science and technology in the United States, discussing in general terms the nature, benefits, and problems associated with the collection, dissemination, use, and value of such information in scientific and technological growth. Studies in the following areas are briefly reviewed: (1) the perception of the national need for information, (2) the identification of sources of information and its availability, (3) the identification and satisfaction of user needs, and (4) the development of a national policy on information. A bibliography provides references for the studies and reports cited in the text. (FM)

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INFORMATION RESOURCES AND THE
GROWTH OF SCIENCE AND TECHNOLOGY
IN THE UNITED STATES

by

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Information Resources and the Growth of
Science and Technology in the United States

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Information has long been recognized as an important factor in the growth of science and technology. As the volume of information has increased dramatically in recent years, numerous new resources have been created. This article reflects the recognition, concern and efforts which have taken place in the U.S. to enhance the availability and utilization of information in furthering the growth of science and technology.

Science and technology play a major role in achieving social, political and economic goals of every country. They also impact on virtually every facet of our daily lives including our work, leisure, transportation, communication and general welfare. In the context of the increasing societal importance of science and technology, the significance of information resources has been highlighted in a number of studies.

This article will deal specifically with studies bearing on the role which information on research and development (R&D) plays in science and technology in the United States. However, it should be stated categorically at the outset that such information, regardless of the country in which it is generated, is of potential interest and benefit worldwide, and as such, except for classified and proprietary research, should have the widest dissemination possible on a global basis.

It is not the intent of this article to discuss in detail the growth of R&D in this country or the results obtained from information derived from such research, but to discuss in more general terms the nature, benefits and problems associated with the collection, dissemination, use, and value of such information in the growth of science and technology, citing selected references which will provide more information than can be covered in a single article of this nature. For the purposes of this paper, information will be considered in a very broad context including R&D literature, bibliographic data, observational data, patents, information on

research in progress as well as socio-economic data relating to research and development activities.

In the past two decades alone there has been an increasing recognition of the importance of information relating to scientific and technical endeavors in part because of the increasing amounts of information which are being generated and the need to improve its dissemination and utilization. This need extends from the individual research investigator up to the policy making level. It is this variation in user need that results in significant differences in the types of information required and the ways in which it is utilized by the various categories of users. In order for information systems to grow there must be both a perceived need and a source of support. In the U.S. as in many other countries, support may come from both the private and public sector for both the establishment and continued use of information systems.

Perception of the National Need for Information

In the U.S. alone there have been numerous studies and reports attesting to the need for scientific and technical information and its communication for a variety of uses, to research investigators, research managers, policy makers as well as the public at large. Many of the papers cited contain extensive bibliographies within them which will lead the reader to many other references of a more specific nature. Among the earlier papers of major interest which can be cited are the Weinberg report¹ and the report by the Committee on Scientific and Technical Communications (SATCOM) of the National Academy of Sciences², both of which emphasized the need for information on research and development in order to improve the nation's science and technology efforts. The reports were primarily directed toward the relationship between the government and private sector and the need for improved communication of information between them. The Weinberg report¹ in

particular stressed the responsibilities of the technical community in this regard. The reports were sponsored by the Executive Branch of the Government and reflected its increased concern with the need for improved use of scientific and technical information. These and a number of other earlier studies are discussed in some detail in the Whalen and Joyce report³ described later in this paper.

These early concerns of the Executive Branch have continued to be reflected over the years by more recent studies and reports, such as the Report of the National Forum on Scientific and Technical Communication (Adams and Rood⁴) which looked at critical issues in scientific and technical communication based on the perception of users and providers of technical information. This report is the result of an analysis of community input obtained during three national conferences sponsored by the National Science Foundation to obtain the views of individuals and organizations in both the public and private sector as well as the opinions of those attending from their perspective as a user, including policy makers, or as a provider of scientific and technical information. In all, some 350 individuals participated in the National Forum sessions on scientific and technical communication. A number of the conclusions reached as a result of these meetings are discussed later in this paper along with other recent papers which call for a national information policy.

The need for information in improving and expanding science and technology has fortunately been recognized not only by the originators and users of much of the information but by legislators as well, a necessary prerequisite if adequate levels of financial support are to be made available to collect and disseminate such information. The interest of U.S. legislators in the importance of scientific and technical information has been equal to that expressed by the Executive Branch of the Government over the past 18 years and is amply demonstrated by numerous Congressional hearings and reports dealing with the transfer of such information.

Among the major legislative hearings and reports which have been published relating to the value of R&D information, its dissemination and utilization are the reports by the U.S. Senate Committee on Government Operations dealing with the coordination of Federal research activities (U.S. Congress, Senate^{5,6,7}); the report of the Select Committee on Government Research (U.S. Congress, House⁸) which followed the process of research efforts from their inception through the dissemination of information on the project and the results generated from such research. An excellent review of these and a number of other Congressional studies dealing with the collection and dissemination of scientific and technical information generated by Federally supported R&D is contained in a report for the Senate Committee on Labor and Public Welfare (U.S. Congress, Senate⁹). This report highlighted the role which the National Science Foundation played in such activities.

While most of the studies cited earlier deal with the transfer and utilization of information in general, there are many other studies relating to the role which information on research and development plays or can play in the development of specific areas of science and technology such as the World Food and Nutrition Study (National Research Council¹⁰) which focuses on a specific subject oriented area and the role which both information and data systems play in the advancement of science and technology in this area. Other studies have highlighted the importance of information on R&D as it relates to innovation (Battelle¹¹) or examined the role of various information-based science indicators as a measure of the growth of science and technology (National Science Board¹²).

Identifying Sources of Information and Its Availability

There are many sources of research information, i.e., systems and services which have been increasing in number steadily over the years. Such sources now encompass collections of primary documents, bibliographic records covering the open

literature and/or technical reports, data bases of ongoing research information, patent information and numerous data bases which contain factual information on chemicals, toxic substances, measurements, etc., collected as a result of R&D in a myriad of disciplines. A recent review by Grattidge and Creps¹³ describes many of the specialized data banks which fall in this latter category. A recent bibliography of online systems covering many information areas has been compiled recently by Hall¹⁴. Hersey¹⁵ has reviewed the growth, development and use of research in progress information systems. The review highlights some of the major differences between such systems and other more conventional information systems.

The growing number of information systems in the U.S. in all areas of science and technology, particularly in the Federal sector has resulted in the development of a number of directories for the identification of such systems, their location and the type of information available. Two major ones include the Congressional Sourcebook Series¹⁶ on Federal Information Sources and Systems and the Directory of Federal Technology Transfer (Executive Office of the President¹⁷) both of which provide a broad coverage of information systems and sources in all scientific disciplines. In recent years discipline oriented directories of research data and information sources have become fairly commonplace. The directories of Federal Environmental Data: A Directory of Selected Sources (National Science Foundation¹⁸), the U.S. Directory of Environmental Sources (U.S. Environmental Protection Agency¹⁹) and the Directory of Criminal Justice Information Sources (U.S. Department of Justice²⁰) are typical of the many specialized directories which have been developed to cope with the ever rising number of specific information resources now available.

The private sector has been no less vigorous in its publication of directories for identifying valuable sources of information as exemplified by the Encyclopedia

of Information Systems and Services (Kruzas and Sullivan²¹). A recent directory, prepared by the Smithsonian Science Information Exchange (SSIE) and compiled in cooperation with UNESCO, identifies a wide variety of research in progress information systems not only in the U.S. but worldwide (SSIE²²). Many professional societies and associations now publish review articles and directories identifying the many new resources for information which are becoming more readily available.

There are many people who believe all information should be made readily available to all people in all forms. While this could be viewed as an ideal goal, it is still one which may never be fully realized even though much progress has already been made towards it. Numerous improvements have been made in recent years in the availability and dissemination of research information. A good illustration of this is the increase in availability of data base information available online. Williams²³ has noted that there were some 33 million bibliographic references available for online searching in 1976 and 50 million in 1977. Online searches likewise increased in the same period from 1,200,000 to over 2,000,000. It should be noted that these figures represent only one approach to availability and use of scientific and technical information. A review describing numeric data bases and systems, many of which are online, has recently been made by Luedke, Jr., Kovacs and Fried²⁴. More recently McCarn²⁵ has completed a broader based review of online systems. This review describes not only the various types of services available from a wide variety of systems but discusses recent papers on the training, costs and evaluation of such systems. A good deal of the literature dealing with online retrieval prior to 1976 has been covered by Hall¹⁴ in an extensive bibliography on the subject. In addition to the bibliography, the compilation included a guide to online data bases and systems. As a result of the many reviews and directories of information resources available to scientific and technical users as well as the general public, they now have a greater awareness of the vast

array of information sources available to them. Ready access to such information sources has undoubtedly greatly enhanced scientific and technical efforts associated with major problem solving on a national level.

Identifying and Meeting User Needs

There have been numerous papers on identifying user needs. Crawford²⁶ in a recent review of information needs and uses estimates that over the past 30 years, some 1,000 papers on user behavior and the use of information systems have been published. Her review covers the literature in this area from 1975 to 1977. Because of her excellent coverage only a few references in recent years will be covered here. It should be noted that over the past ten years major changes have taken place in the number and availability of information resources, and modern technology has contributed significantly to improved packaging, availability and dissemination of information as a result of which many new user demands have now evolved.

The workshop report by Freeman and Rubenstein²⁷ on Users and Uses of Scientific and Technical Information - Critical Research Needs contains a good deal of information generated by the 21 representatives who attended and participated in that meeting. This group noted that the highest but not exclusive priority should be given to research projects that dealt with the marketing aspects of scientific and technical information systems such as finding more useful ways to categorize users and more effective means of familiarizing potential users with such systems to increase their use.

Freeman and Katz²⁸ in a recent review of information marketing note that the term marketing, particularly as it is used by non-profit and public organizations is most often labeled as user needs or user education and the economics of information. The goal, whether in the public or private sector is

essentially the same, identifying and meeting user needs and thus providing a satisfactory service to those with an expressed need. Their review covers various factors that impact on user needs and the various ways in which they are perceived and met, as well as the impact that user fees and the development of a national information policy might have in the future. It also touches on the public and private sector competition which exists in providing information to meet user needs. This latter item is particularly important and one which has been stressed in a number of papers including those mentioned later in this article relating to the development of a policy on information. Berninger and Adkinson²⁹ have recently reviewed the interaction between the public and private sector as it relates to the dissemination of information in the U.S. The review includes an extensive bibliography on the numerous papers which have appeared on this subject.

The recent report by Adams and Rood⁴ contains an extensive discussion of user needs as they relate to scientific and technical communication. The summary of this report stresses problem areas and recommendations for their solution which were perceived by users, purveyors and policy makers during three national conferences sponsored by the National Science Foundation. A detailed analysis of the comments generated by the three categories of attendees is included in this report.

In addition to determining user needs there is the problem of developing ways in which to enhance the use of information in R&D laboratories so as to maximize the value of such information. Two recent studies may prove useful in this regard. The study by Shapero et al.³⁰ is particularly noteworthy for its efforts to identify specific managerial means for enhancing scientific and technical information usage in R&D organizations. On a more general level, the study by Rubenstein et al.³¹ identifies a number of experiments which might be carried out to help improve overall scientific and technical information

effectiveness from the viewpoint of users. The report is based on an analysis of the literature and surveys of users and ongoing experiments by users and explore the feasibility of a framework for analysis of the information transfer process.

Thompson³² in a review of technology utilization discusses a large number of papers relating to the communication and utilization of information in scientific and technical activities.

Clearly much remains to be learned about user behavior and user needs if we are to maximize the impact scientific and technical information will have in enhancing the growth of science and technology and the benefits to be derived therefrom in the future.

Development of a National Policy on Information

The studies cited earlier deal mainly with the assimilation and use of all types of information and data on research, identification of sources of information and its availability, and the communication or dissemination of such information to various types of users ranging from bench level scientists to research managers and policy makers. Also noted has been the growth and development of data base information systems which specialize in various types of information as well as those which range from very specific subject areas to those that cover multidisciplinary areas including those which are specifically mission oriented. Superimposed on all of these information activities has been the desire on the part of many to see the development of a national information system or minimally a national information policy.

Earlier in this paper I referred to a number of studies relating to the recognition of scientific and technical information as a valuable national resource in the R&D process. Many of these studies are also germane in relationship to a recommendation to establish a focal point for the direction and review of scientific

and technical information activities in the Federal Government structure, including those by Weinberg¹, National Academy of Sciences (SATCOM)² and Adams and Rood⁴. Three recent reports, the report of the Domestic Council Committee on the Right of Privacy³³ on National Information Policy, the Burkhardt report³⁴ prepared by the National Commission on Libraries and Information Science and the Whalen and Joyce report³, prepared by the Mitre Corporation for the National Science Foundation, have further emphasized the need for the establishment of a focal point in the Government for the direction and review of information activities. The latter study is particularly helpful in that it draws together and reviews many of the earlier reports in terms of the actions and recommendations which were made by other studies regarding information policy issues. The report was particularly germane in light of the National Science and Technology Policy, Organization and Priorities Act passed in 1976 which reflected the concern of Congress as well as other groups about the nation's scientific and technical information activities. This new law, while recognizing and addressing scientific and technical information matters rather extensively, does not establish any specific mechanisms for dealing directly with national scientific and technical information problems several of which are expected to be addressed by offices or committees created under the Act.

One of the latest reports to emerge, the A. D. Little Report³⁵ prepared under the leadership of V. Guiliano, its project director, for the National Science Foundation, presents an excellent overview of the growth and development of information transfer and the multiplicity of organizations involved in it. The report identifies three continuing Eras of scientific information transfer: the first and oldest Era emphasized the transfer of information on a disciplinary basis; the second, a post World War II Era, has been devoted to the transfer of mission oriented information; and a most recent, emerging Era has been directed

towards complex socio-economic-technical systems problems in areas such as energy, environment, health, etc. Using this concept as a base for their study, the authors have identified the differences in information transfer among the three Eras covering extensively current issues and problems of the most recent Era suggesting possible action steps to improve the present infrastructure.

The study is particularly noteworthy because it recognizes the value of research information not only for use in science and technology per se but its value in the solving of societal-economic problems of much broader dimensions as well. It brings together more clearly than other studies the interrelationships between the generators, purveyors and users of information and particularly the relationship which must exist between the Government and private sector in terms of their roles as disseminators of scientific and technical information. The study notes that changes will take place in the foreseeable future and suggests ways in which the change process might be stepped up.

The report notes in particular that a shared conceptual framework of the overall problem and its solution at the national level could be the basis for a stepped up legislative remedy if the underlying issues were more clearly understood by a greater number of the stakeholders involved. The authors concur in general with the Domestic Council Committee report³³ cited earlier, that the U.S. should pursue the development of a coordinated national information policy; that an Office of Information Policy should be established in the President's Office and that a Federal Interagency Council on Information Policy and an Advisory Committee should be established to work with the Office of Information Policy, with representatives from local governments, academic and professional groups as well as the business sector.

The U.S. Congress itself has most recently expressed its growing concern in a booklet issued by the Subcommittee on Science, Research and Technology of

the House Committee on Science and Technology³⁶. This booklet, Optimizing the Value of U.S. Scientific and Technical Information: Legislative Options, draws together in a very concise way the gist of many of the key reports and laws which have been made over the past two decades and suggests some of the legislative initiatives and options which the Congress might consider over the next few years.

Outlook for the Future

It is clear that in the U.S., both the Government and private sector have increasingly recognized the value of research information not only in science and technology per se, but in the context of a much broader scope which includes the development of new technologies. Information systems not only stimulate economic growth, but have the potential to provide a greater capability for solving societal problems as they arise. There are clearly many problems to be solved and further steps to be taken if we are to maximize the benefits to be gained from the mass of information which is continually being generated by our research and development efforts. It is becoming more apparent with each new report what the problems are and who the stakeholders are, so that over the next few years we can anticipate significant progress in the resolution of these issues not only at a national level but hopefully in a way which will benefit all mankind.

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